On-sky Image Quality Verification / Compensation Plan

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Hanshin Lee

Outline

- **Expected alignment-drive aberrations contributing to the image quality degradation**
  - Major terms : Field constant coma, Field linear curvature/astigmatisms.
    - Additionally, field quadratic coma and field cubic astigmatisms can contribute.
  - All these terms are linearly coupled to alignment parameters.

- **Available compensators and their influences**
  - WFC motions
    - Decenter : Strongly image position, weakly field constant coma.
    - Tip/tilt : Strongly field constant coma, weakly field linear curvature/astigmatism.
  - Focal Surface (FS) motions
    - Decenter : Strongly image position, weakly field linear curvature.
    - Tip/tilt : Strongly field linear curvature.

- **First-order plan**
  - Align FS with respect to WFC.
  - Point HET to on-sky target (geostationary satellite) on-axis and minimize coma by tilting WFC.
  - Point to the target at off-axis FS positions and measure curvature.
  - If necessary, minimize field linear curvature by tilting the FP

Layout & Error budget

- **Three major subsystems**
  - Focal Plane Assembly (FPA)
  - Wide Field Corrector (WFC)
  - Primary Mirror (M1)

- **Critical alignment**
  - WFC – FPA
  - M1 – WFC
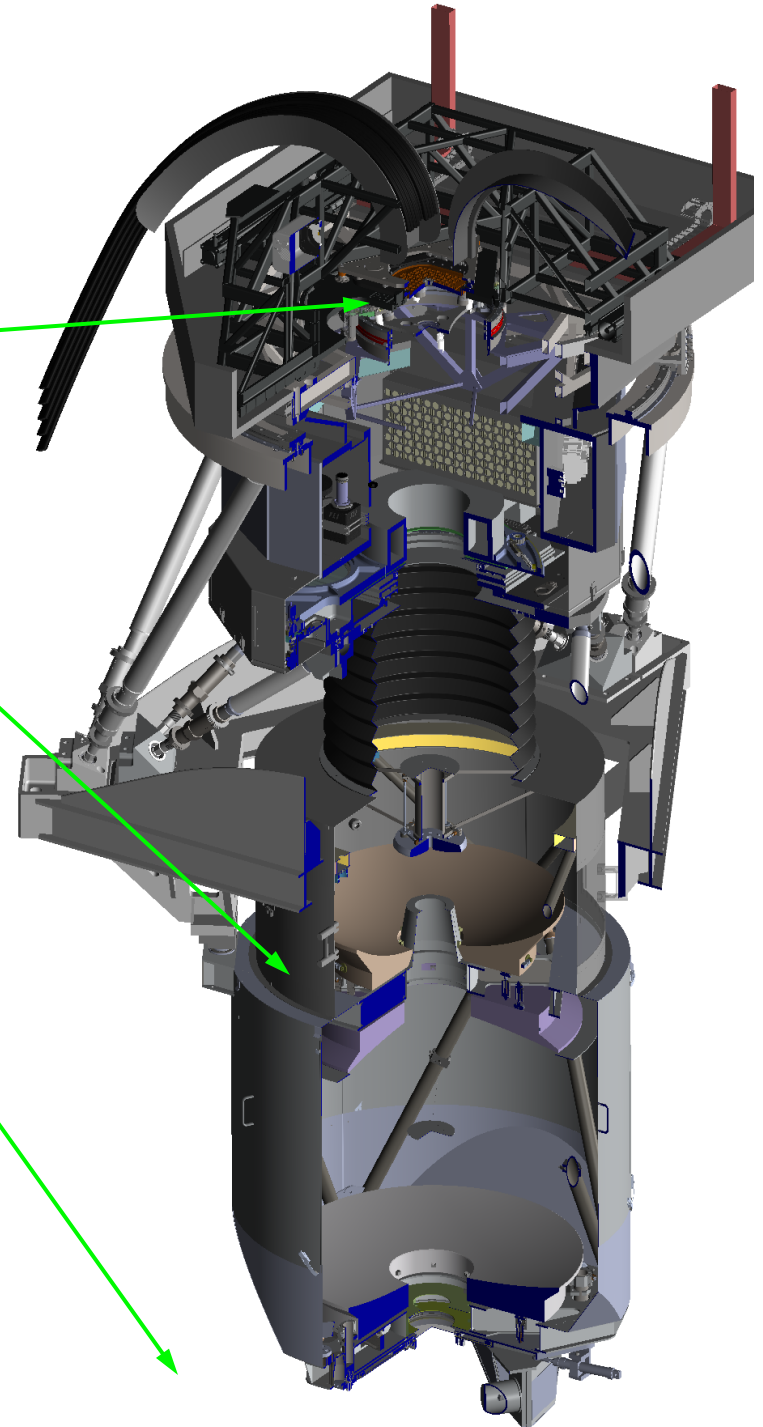
- **Static alignment error budget**
  - WFC-FPA
    - Focus: ±0.3mm
    - Centration: ±0.17mm ⎤
    - Tilt: ±90arcseconds ⎦ 0.19wv linear curvature
  - M1-WFC
    - Focus: ±0.01mm
    - Centration: ±0.01mm ⎤
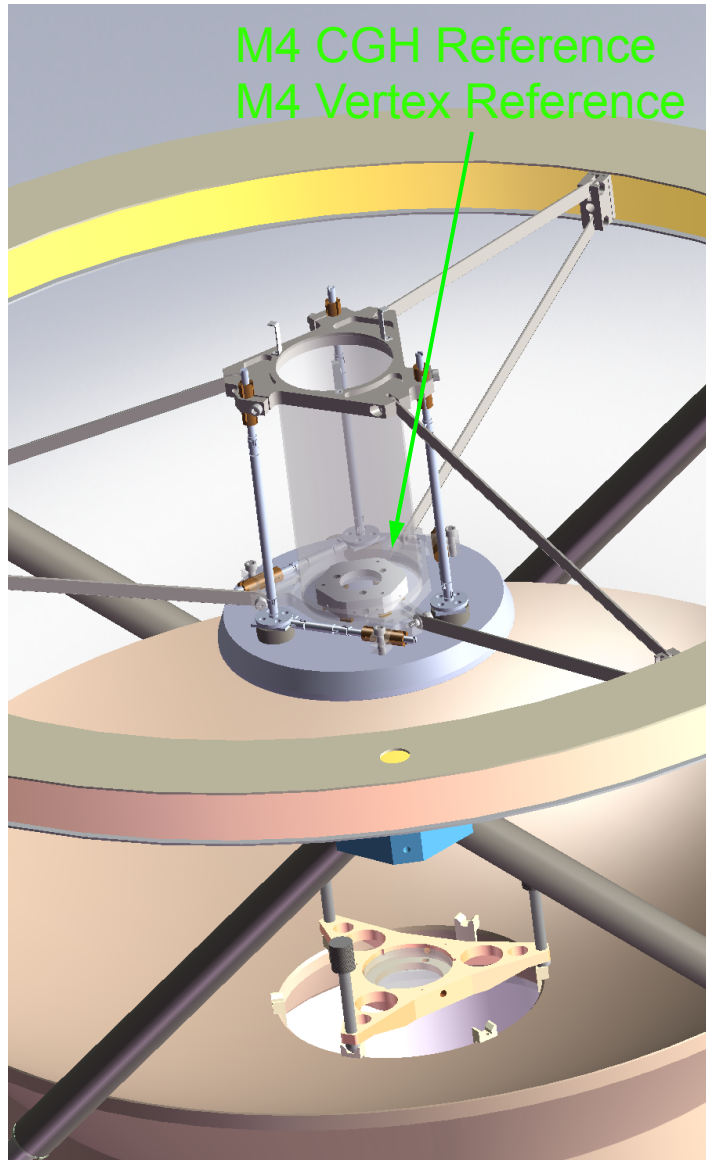   - Tilt: ±4arcseconds ⎦ 0.33wv coma

WFC-FPA Alignment Scheme

- Set up Video Alignment Telescope (VAT) at M3 Strongback centered/ normal to M4 CGH Reference.

- Reticle target in FPA is aligned to M4 CGH Reference in centration/tilt

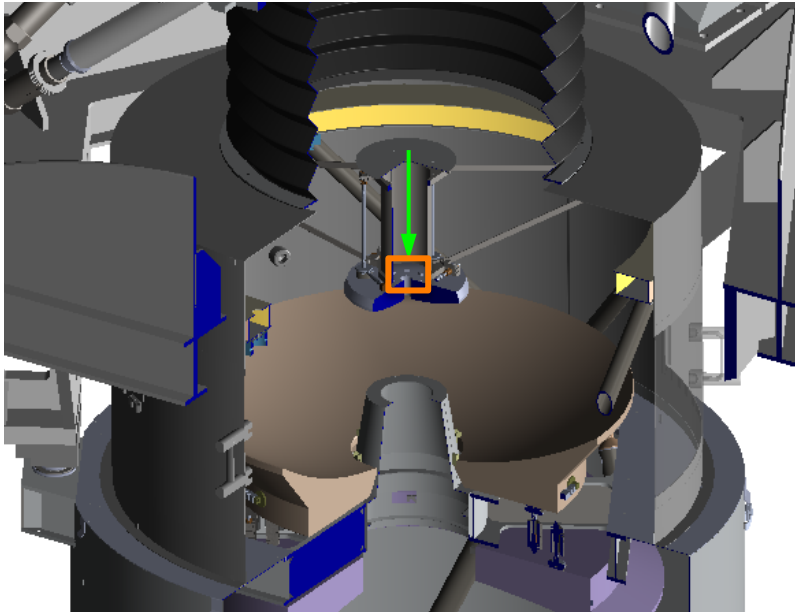- SMR target in FPA is aligned to M4 Vertex Reference in focus
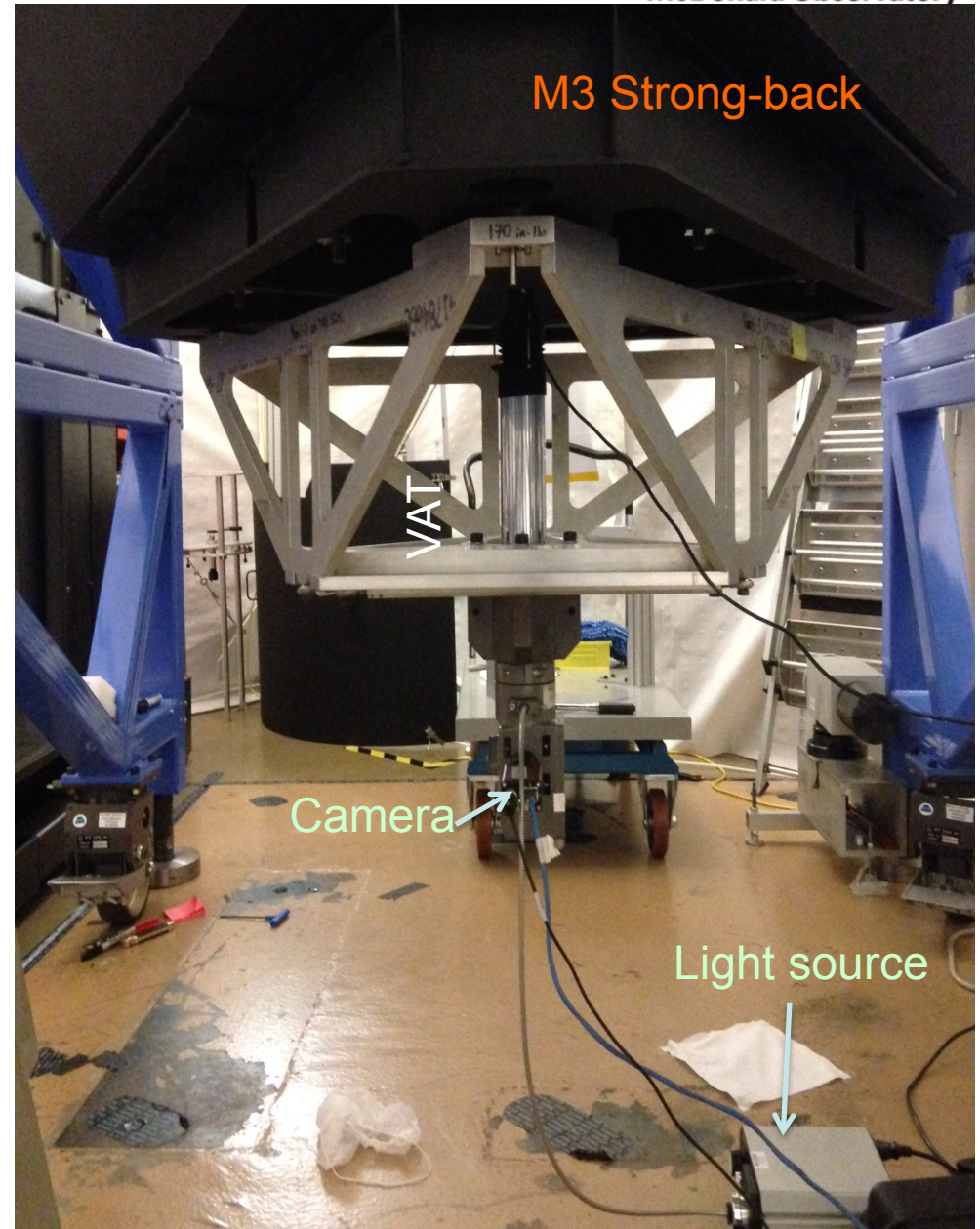

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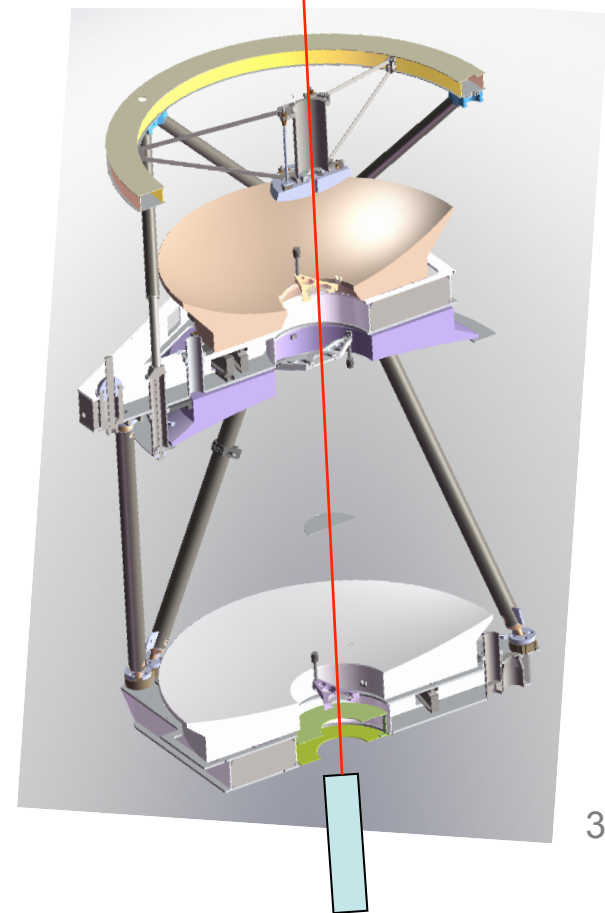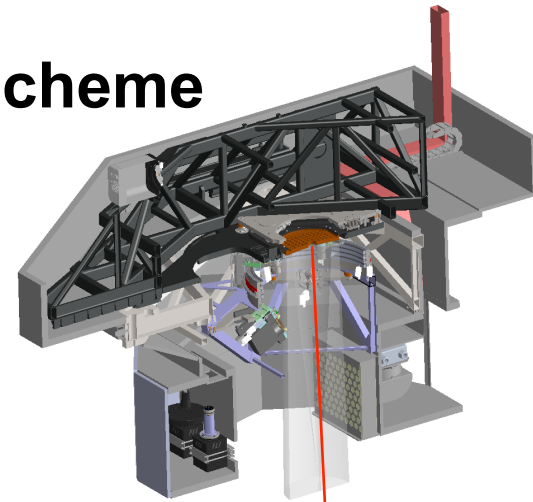
M4 CGH Reference
M4 Vertex Reference
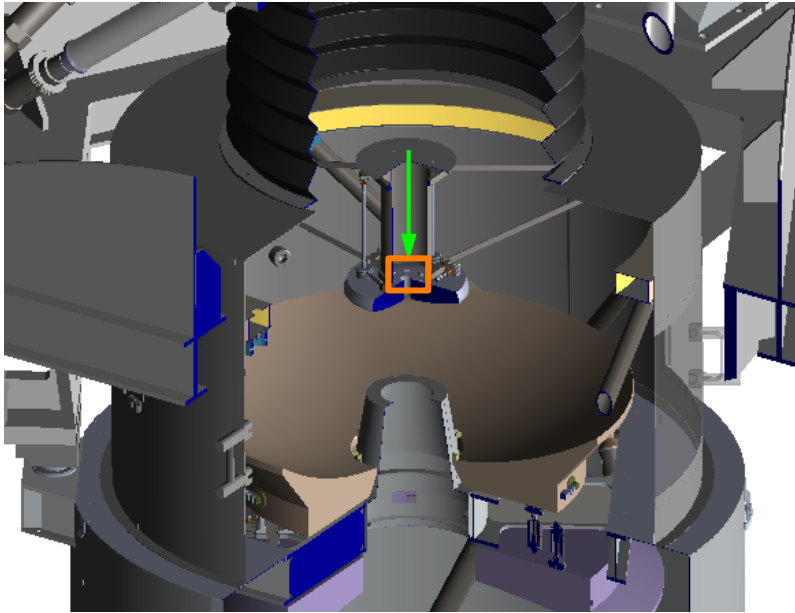
Picture of M4 CGH Ref

Picture of M4 VTX Ref

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Video Alignment Telescope

- **VAT aligned to M4 CGH Reference to the following accuracy estimate (based on previous tests)**
  - Centration: ±0.01mm at 3σ
  - Tilt: ±5arcseconds at 3σ

M3 Strong-back

VAT

Camera

Light source

API Laser Tracker

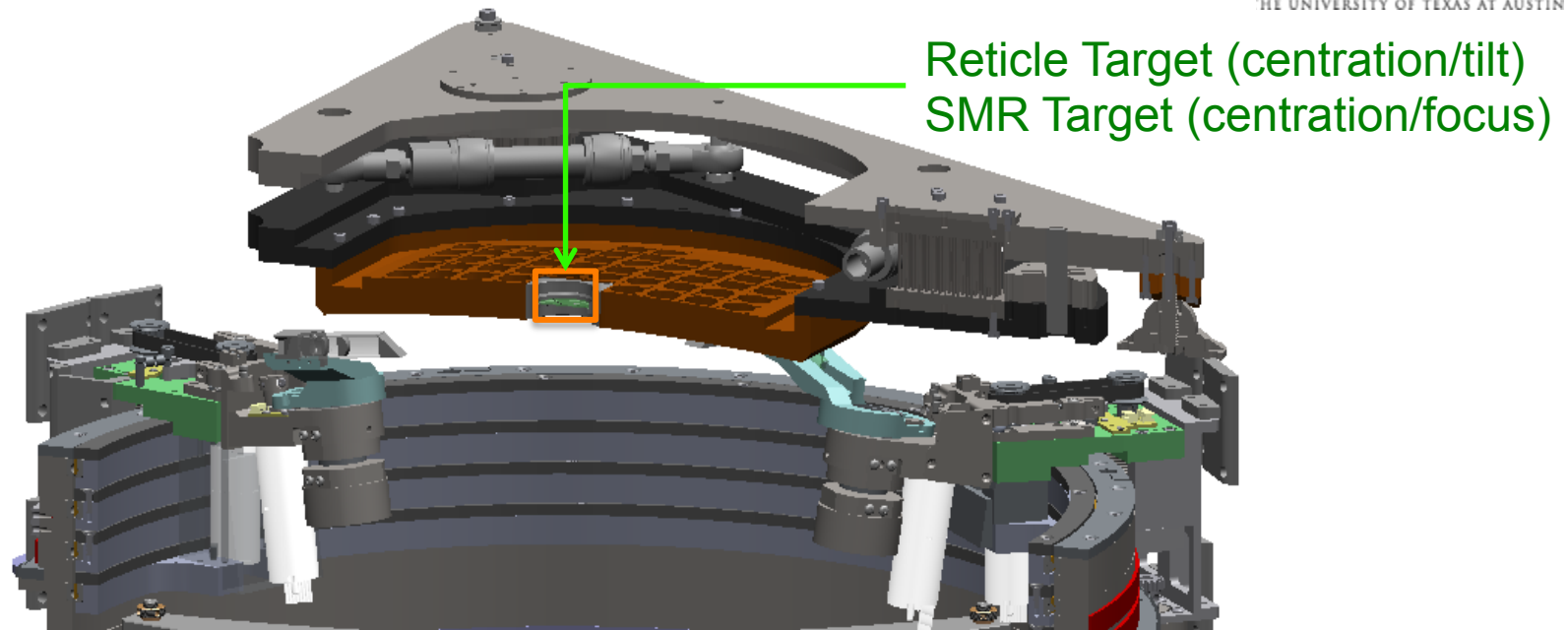Laser tracker mounted on the Tracker (Picture)

- **LT to M4 Vertex Reference**
 - Focus: ±0.025mm(?) at 3σ.

FPA Targets

Reticle Target (centration/tilt)
SMR Target (centration/focus)

- **FPA targets installed to the focal surface**
  - Centration accuracy:±0.025mm at 3σ (Reticle/SMR)
  - Tilt accuracy: ±10arcseconds at 3σ (Reticle)
  - Focus accuracy: ±0.015mm(?) at 3σ (SMR)
- **Using VAT (wrt M4 CGH reference), align FPA Target in centration/tilt**
  - Centration measurement accuracy: ±0.05mm at 3σ
  - Tilt measurement accuracy: ±5arcseconds at 3σ
- **Using Laser Tracker (wrt M4 Vertex reference), align FPA target in focus**
  - Focus measurement accuracy: ±0.05mm(?) at 3σ

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SMR Target

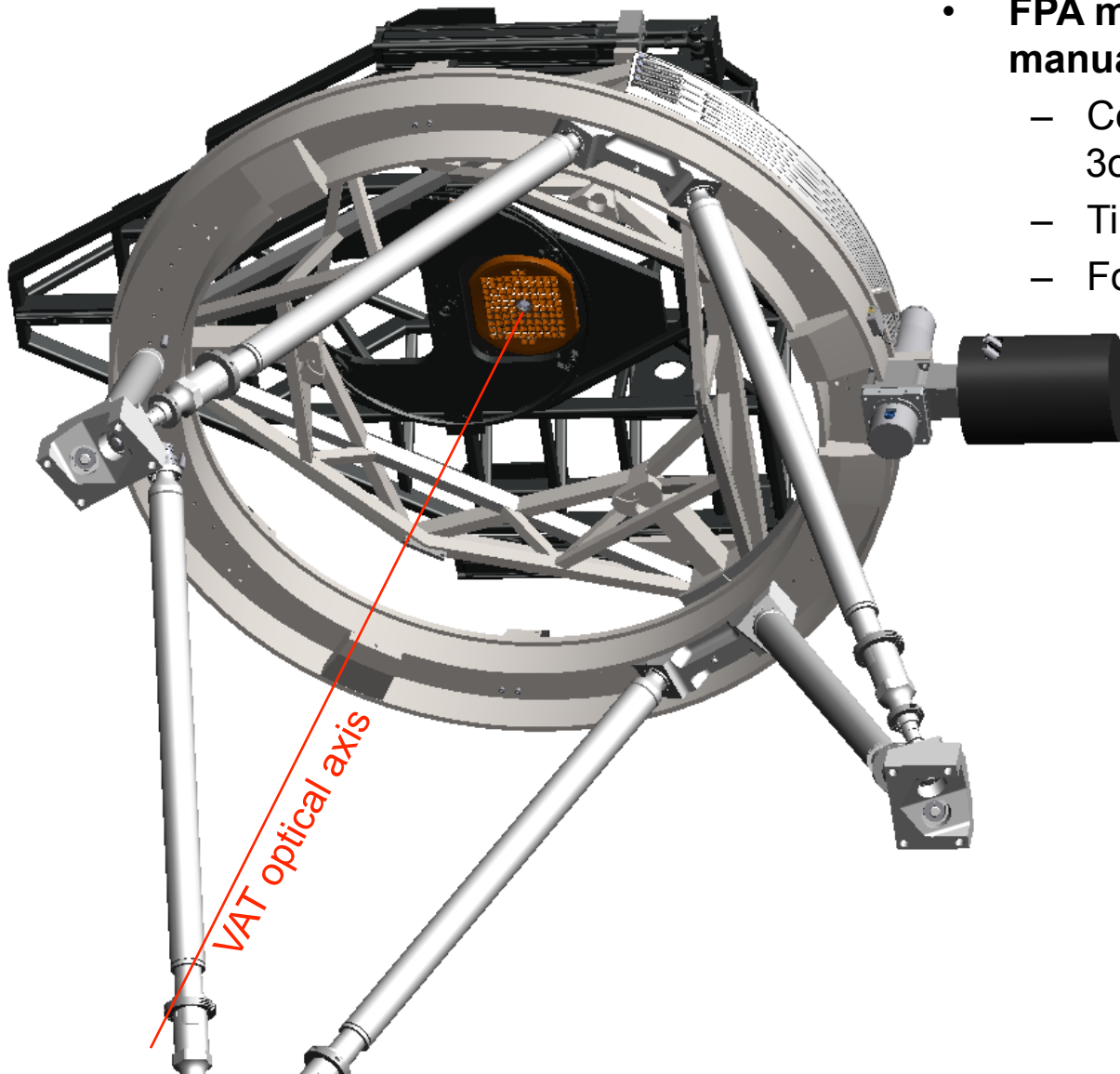SMR nest
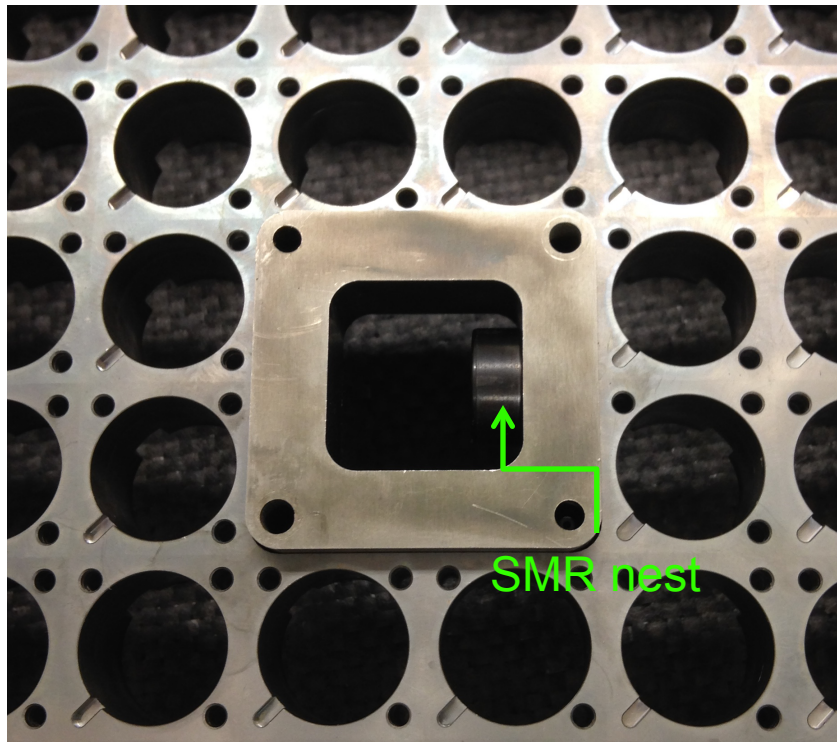
Reticle Target Picture
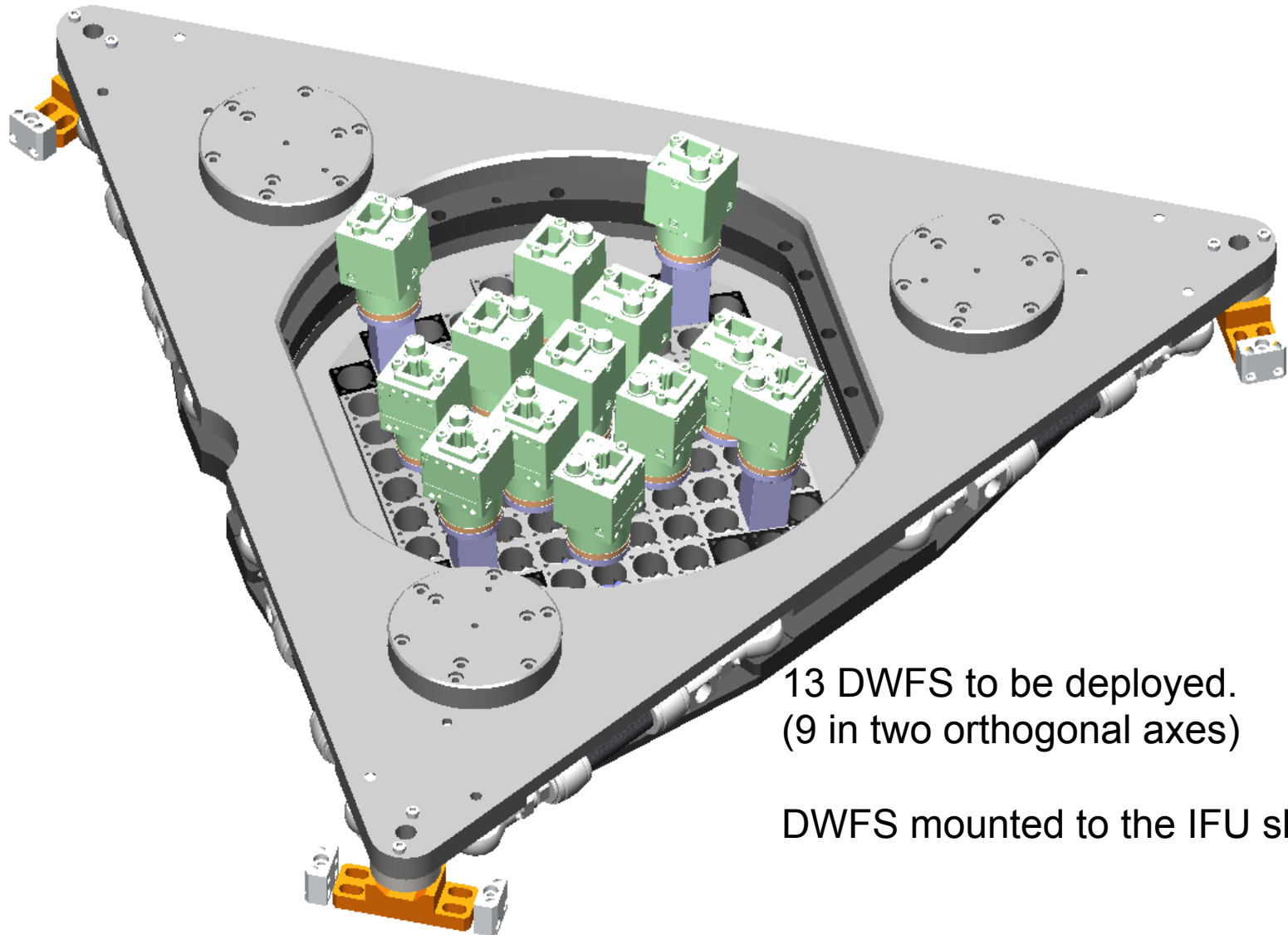
- **FPA mounted to the Rho stage on a manual hexapod**
    - Centration control accuracy: ±TBD at 3σ
    - Tilt control accuracy: ±TBD at 3σ
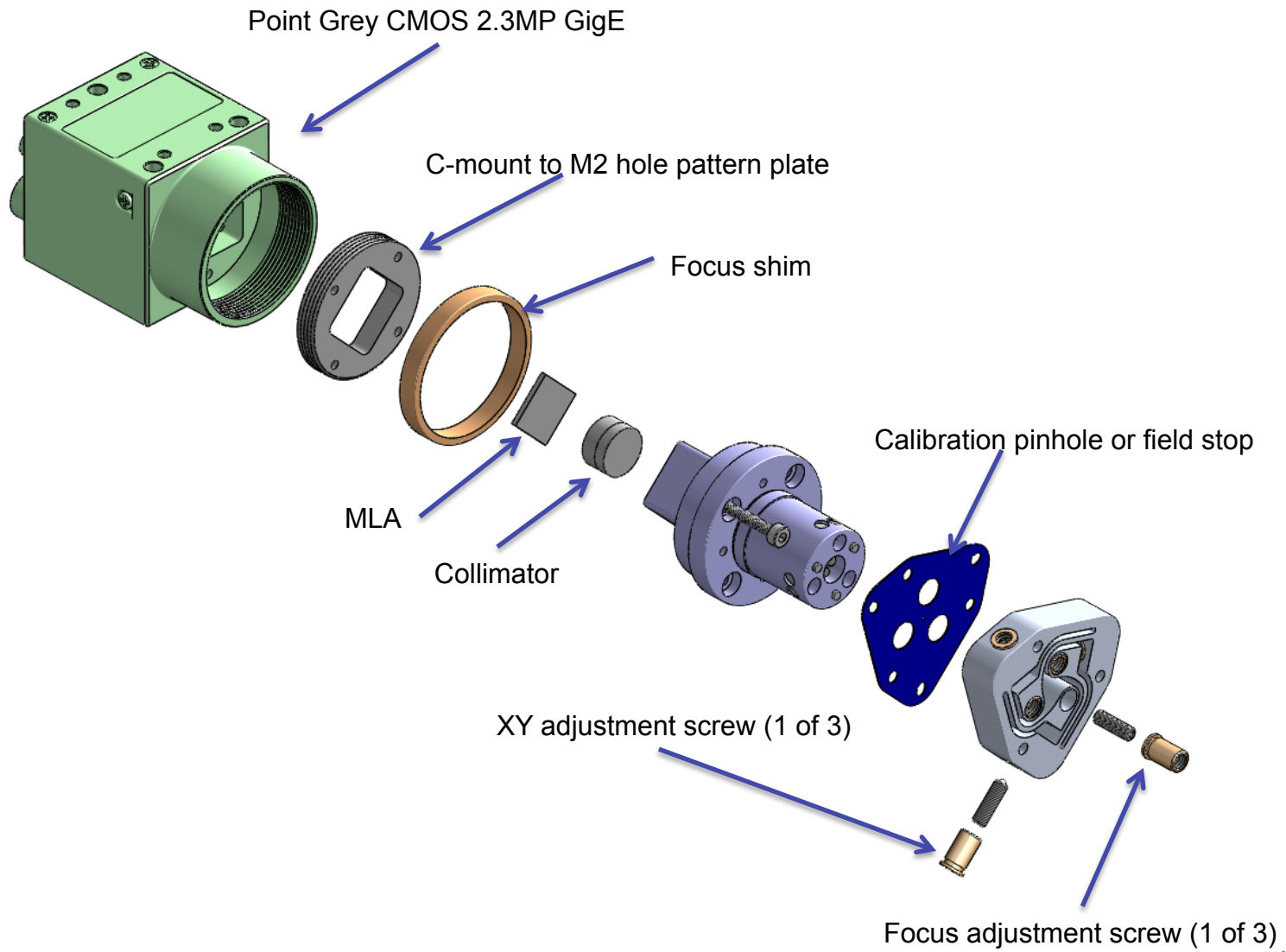   - Focus control accuracy: ±TBD at 3σ

VAT optical axis

Deployable Wavefront Sensor (DWFS)

13 DWFS to be deployed.
(9 in two orthogonal axes)

DWFS mounted to the IFU slots

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Point Grey CMOS 2.3MP GigE

C-mount to M2 hole pattern plate

Focus shim

Calibration pinhole or field stop

MLA

Collimator

XY adjustment screw (1 of 3)

Focus adjustment screw (1 of 3)

Deployable Wavefront Sensor (DWFS)
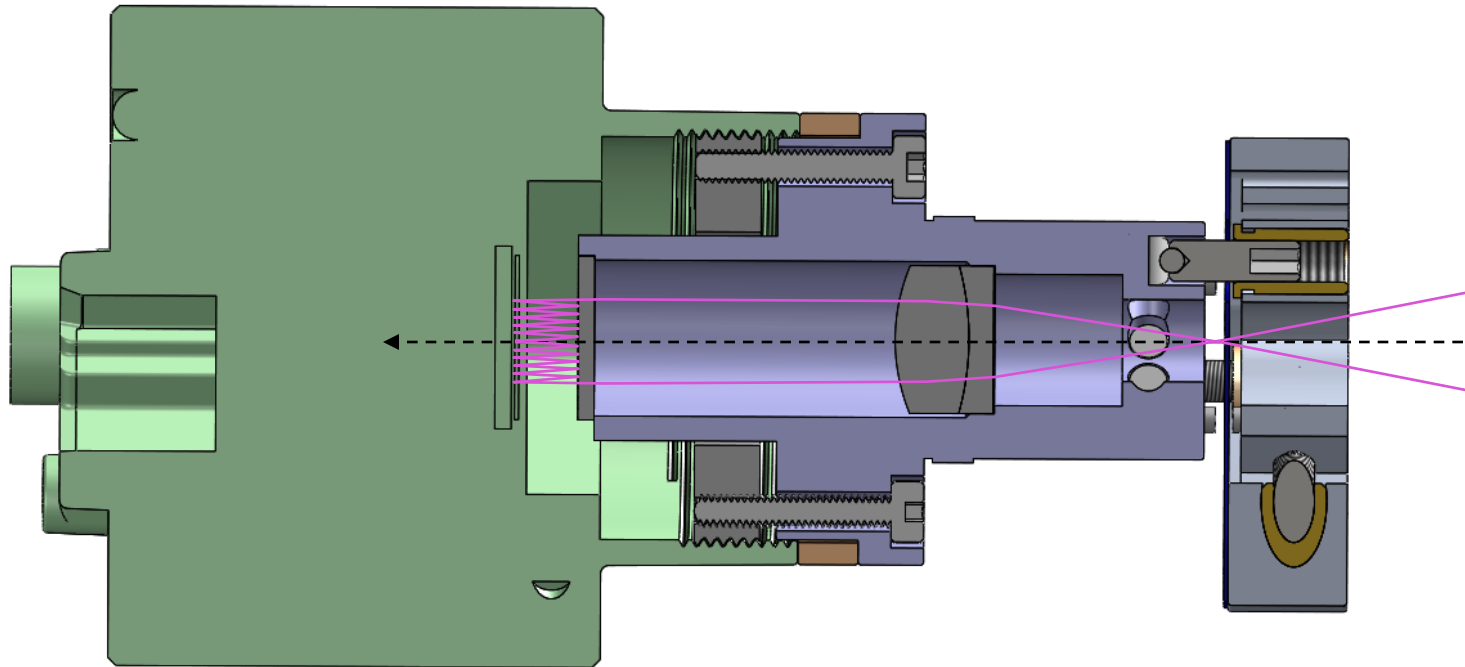
- **DWFS parameters (Hartmann-Shack Sensor)**
  - Detector: 5.86 microns pixel, 82% QE, 50 fps, Global shutter
  - Pixel scale: 0.14 arcsec.
  - Field of View: 6 arcsec diameter.
  - MLA pitch: 0.25mm diameter (Hexagonal shape)
  - Sub-aperture density across HET pupil: 19 (Hexagonal grid)
  - Maximum mode to be sensed: Up to Zernike #55 (radial order 10).
 - Calibrated accuracy: 0.01wv(TBD) per mode at 3σ

Deployable Wavefront Sensor (DWFS)
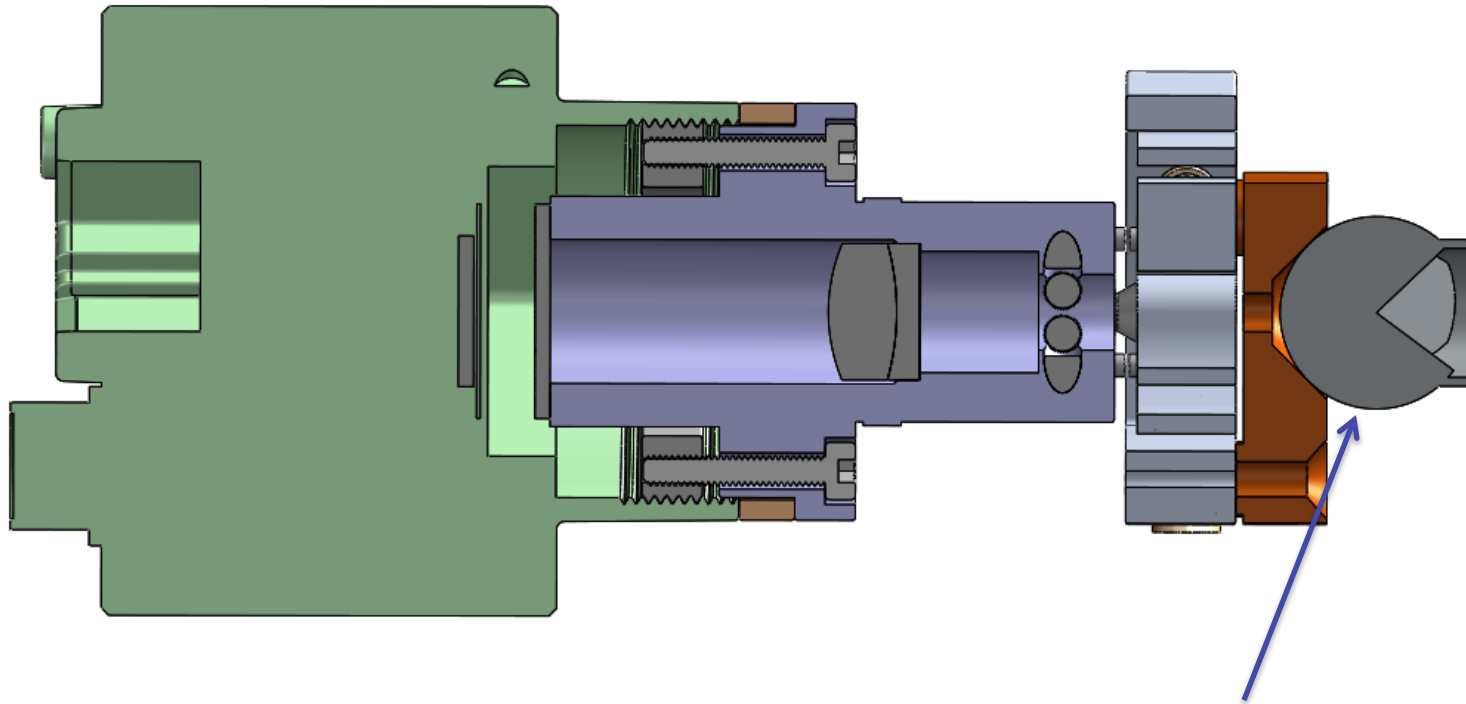
Laser tracker SMR registered to the Field stop of DWFS.
This is used to locate the DWFS field stop within the focal surface.
Registration of SMR to the field stop: ±0.005mm(?) at 3σ.
Repeatability of the KM: ±0.005mm(?) at 3σ.
LT measurement of SMRs within FPA: ±0.025mm(?) at 3σ.

Place holder for the actual fixture
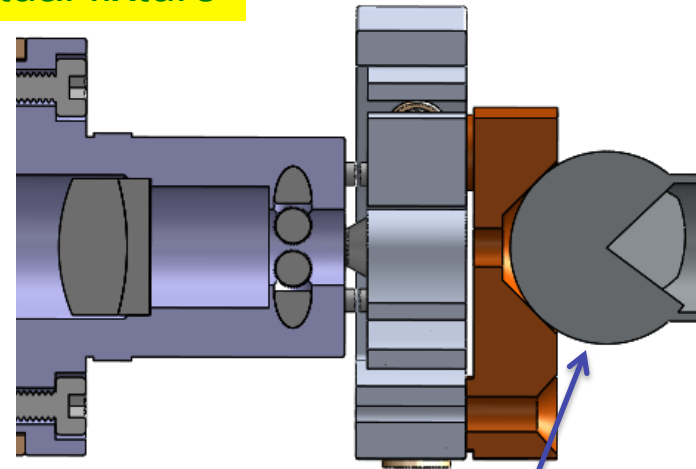
Laser tracker SMR registered to the true focal surface.
Referencing the back of the skullcap (made accurately to the central boss): accuracy ±0.005mm(?) at 3σ.
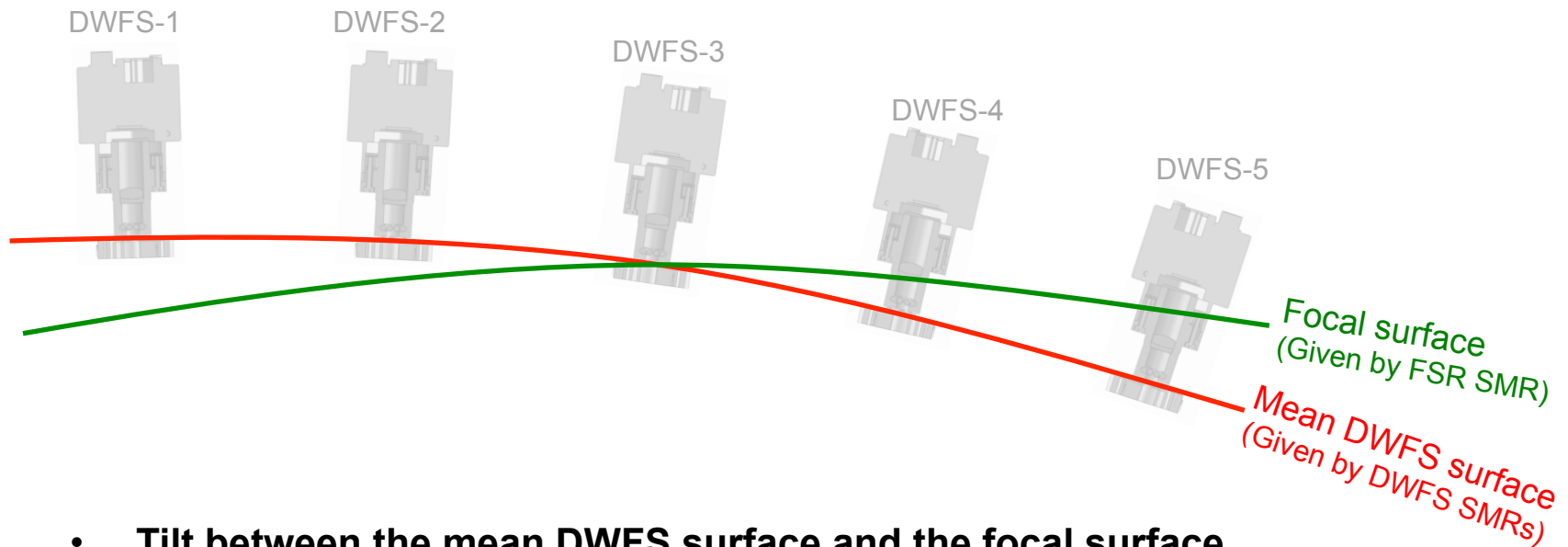The same fixture inserted to all IFU slots in sequence.
Mean surface constructed from the measured position of SMR at different IFU slots corresponds to the true focal surface.
SMR registration to the mounting flange: ±0.005mm(?) at 3σ.
LT measurement of SMR within FPA: ±0.025mm(?) at 3σ.

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Critical alignment (tilt)

- **Tilt between the mean DWFS surface and the focal surface**
  - Focal surface tilt is used to correct the linear field curvature.
  - Systematic tilt between two surfaces results in error in the linear field curvature measurement
  - The tilt can be known to the accuracy of ±64(?) arcsec at 3σ.

Roll-up of WFC-FPA-DWFS alignment error estimate

Contributor	Focus (μm)	Centration (μm)	Tilt (arcsec)	Comment
FPA Target setup	15	25	10	Installation accuracy
VAT cent/tilt to M4 CGH	-	10	5	Measurement accuracy
VAT cent/tilt to FPA Reticle	-	50	5	Measurement accuracy
LT focus to M4 VTX	25(?)	-	-	Measurement accuracy at 2m
LT focus to FPA SMR	50(?)	-	-	Measurement accuracy at 4m
Manual hexapod control	TBD	TBD	TBD	Not counted for now
Deviation of the mean DWFS surface wrt focal surface	36(?) (maximum)	small	64(?) (maximum)	Registration / measurement accuracy (assuming all errors go to either focus or tilt)
Cumulative	**68**	**57**	**65**	**RSS at 3σ**
Requirement	300	170	90	